

# GEST DC Study

## Gestational ExpoSure to Traffic pollution in the DC metro area

### Commute exposure



PI: Anna Pollack, *Epidemiology*

### Visualization tools



Co-PIs: Vivian Motti, *Human computer interaction*; Yi-Ching Lee, *Psychology*

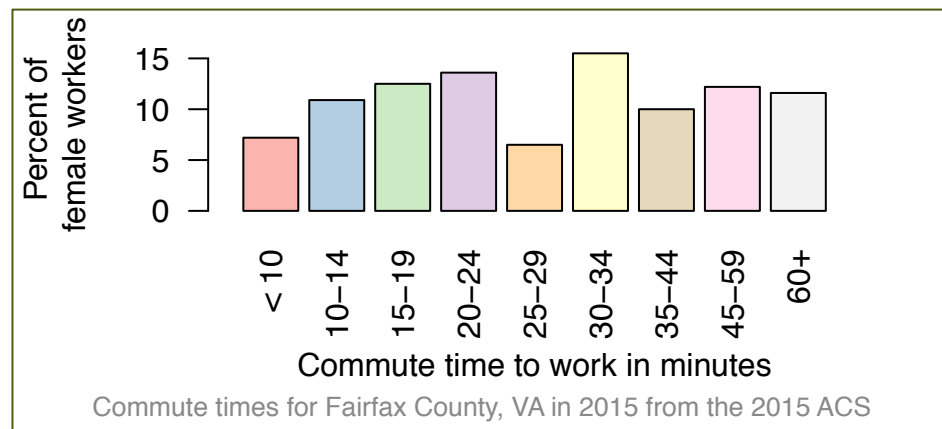
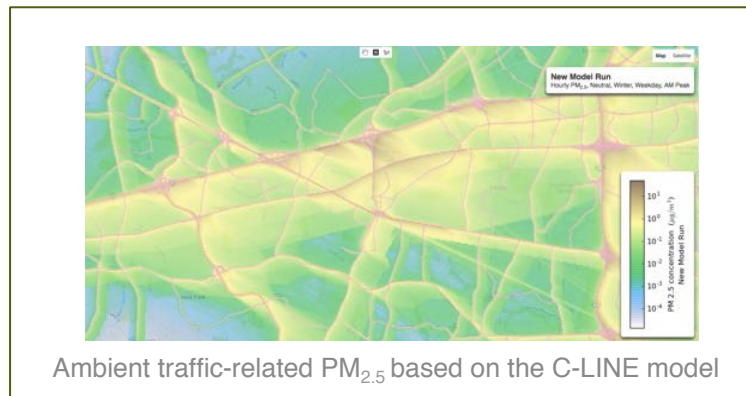
### Statistical methods



PI: Jenna Krall, *Statistics*

# Background

- **Ambient air pollution** is associated with **3 million deaths** worldwide each year.<sup>1</sup>
- **Traffic-related air pollutants (TRAP)** may be particularly harmful and include nitrogen oxides, fine particulate matter (PM<sub>2.5</sub>), and its constituents such as organic carbon, elemental carbon, and metallic species.<sup>2-4</sup>
- **Exposure to air pollution during pregnancy** may increase risk of pre-term birth, low birthweight, gestational diabetes, and preeclampsia.<sup>4-6</sup>
- **Women in the DC metro area**, compared with other cities,
  - are employed at higher rates (64.1% vs. 55% in LA and NYC).<sup>7</sup>
  - have long, congested auto commutes (>82 delay hours annually).<sup>8-9</sup>



**No previous studies have comprehensively examined gestational exposure to TRAP during daily commutes and how women can modify their exposures.**

\*Note: Full references available upon request. <sup>1</sup>World Health Organization (2016) "Ambient air pollution: A global assessment of exposure and burden of disease"; <sup>2</sup>Andersen et al. (2011) AJRCC; <sup>3</sup>Health effects Institute; <sup>4</sup>Bell et al. (2010) Epidemiology; <sup>5</sup>Sapkota et al. (2012) Air Quality, Atmosphere & Health; <sup>6</sup>Malmqvist et al. (2013) Environmental Health Perspectives; <sup>7</sup>Bureau of Labor Statistics; <sup>8</sup>Texas A&M Transportation Institute (2015) Urban Mobility Scorecard; <sup>9</sup>American Community Survey.

# Project goals

## Aim 1. Commute exposure:

Characterize personal exposure to TRAP during daily commutes for pregnant women.



PI: Anna Pollack, *Epidemiology*

## Aim 3. Visualization tools:

Create visualization tools to enable pregnant commuters to track their TRAP exposures.



Co-PIs: Vivian Motti, *Human computer interaction*; Yi-Ching Lee, *Psychology*

## Aim 2. Statistical methods:

Develop novel statistical methods for estimating integrated exposure to TRAP during commutes.



PI: Jenna Krall, *Statistics*

# Project description

**Aim 1.** Characterize personal in-vehicle exposure to TRAP during daily commutes for pregnant women.

PI: Anna Pollack, Epidemiology

Research Team: Jonathan Thornburg, RTI; Jenna Krall, Statistics;  
Leah Babin, graduate research assistant, Global and Community Health



## Approach

### Study recruitment

- Enroll 50 women from obstetric clinics in the northern Virginia metro area
- Inclusion criteria:
  - 1<sup>st</sup>-2<sup>nd</sup> trimester
  - live in the northern VA
  - commute >15 minutes to work by personal vehicle at least 3 days per week
- *We will seek approval for this study from the GMU Institutional Review Board*



### Baseline survey

- Age
- Parity
- Race and ethnicity
- Education
- Income
- Average daily commute length
- Average daily commute time
- Number of days spent commuting per week
- Type of vehicle for commute



### Commute TRAP measurement

- Select one daily morning commute (Tuesday-Thursday)
- Sample in-vehicle exposure to PM<sub>2.5</sub> using MicroPEM™ personal exposure monitors from RTI
- Characterize average in-vehicle exposure to PM<sub>2.5</sub>

## Novelty

- **Characterize in-vehicle gestational exposure** to TRAP, which is currently not well understood
- MicroPEM™ is **lightweight, portable** and can be used while commuting
- Demonstrate feasibility for studies of **gestational TRAP exposure and health**

Establish a **collaboration with RTI** to use MicroPEM™ PM<sub>2.5</sub> personal exposure monitors in environmental and epidemiologic studies



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Photo source: rti.org

# Project description

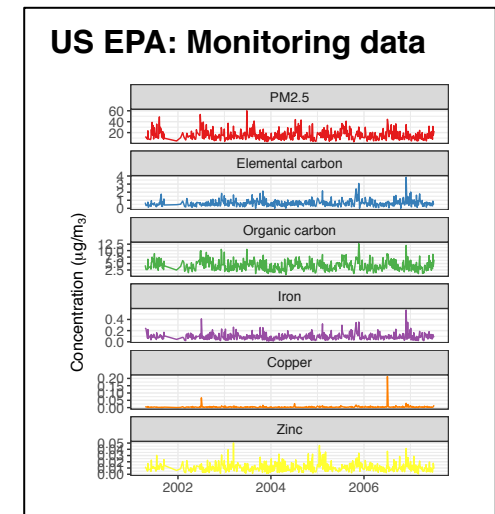
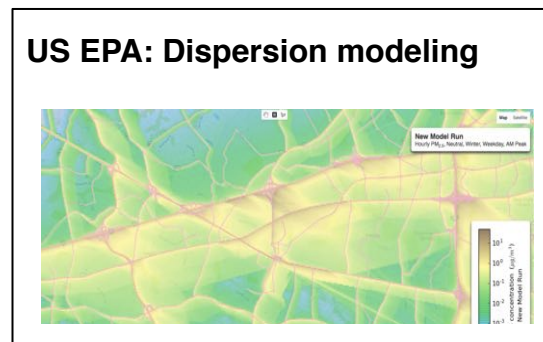
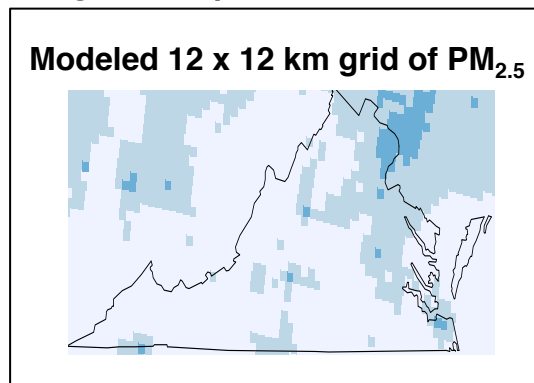
**Aim 2.** Develop novel statistical methods for estimating integrated exposure to TRAP during commutes.

PI: Jenna Krall, Statistics

Research Team: Daniel Tong, CSISS; Cara Frankenfeld, Epidemiology; Vadim Sokolov, Engineering



## Integrated exposure

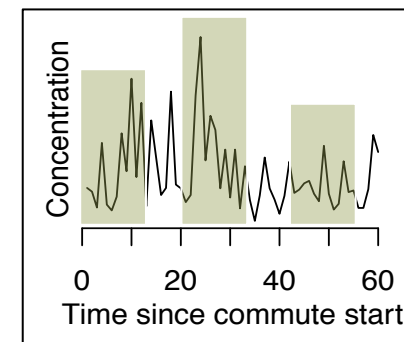


## Approach:

- Develop prediction model for in-vehicle PM<sub>2.5</sub> exposure:  $y_i = \beta_0 + \beta_1 PM_i + \beta_2 time_i + \beta_3 hwy_i + \beta_4 temp_i + \epsilon_i$
- Partial-commute prediction method**: novel method for “small -big data” problem,
  - Prediction model validation using partial commutes
    - divide  $y_i$  for commute  $i$  into partial-commutes  $y_{ij}$
    - predict  $y_{ij}$  using all  $y_{i',j'}$ , where  $i' \neq i, j' \neq j$
  - Develop time-activity matrix to incorporate survey questions about commute

## Novelty:

- Existing methods cannot estimate exposure to TRAP during commutes
- Previous studies do not include (1) in-vehicle monitoring and (2) modeled PM<sub>2.5</sub> at 12 x 12 resolution





# Project description

**Aim 3.** Create visualization tools to enable pregnant commuters to track their TRAP exposures.

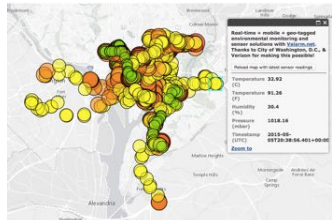
Co-PIs: Vivian Motti, Human-Computer Interaction; Yi-Ching Lee, Psychology



## Existing tools

Generally focus on ambient pollution

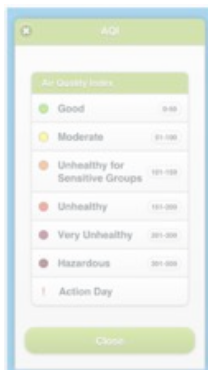
### Valarm Air monitoring



### City Air



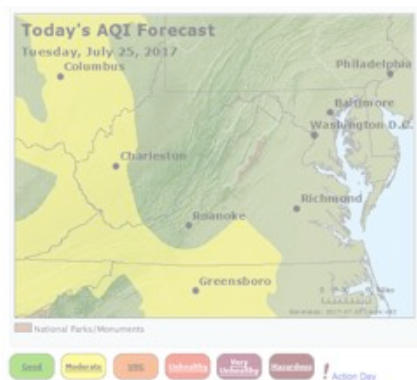
### Clean Air Partners



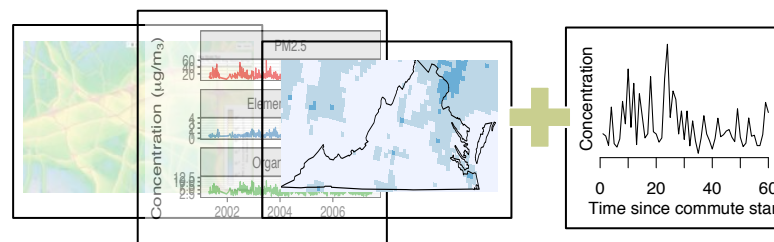
## Approach

User-centric design and development of an online application to deliver personalized information for pregnant women about their **commute-specific exposures to TRAP**

### US EPA Air Quality Index



### Statistical models for commute exposure to TRAP



## Novelty

Design tailored to the users' needs, personalized by:

- Location
- Commute times
- Commute length

**Closing the loop between novel statistical methods and end users.**

### OAVYB App



### Alima air quality app



# Project team

## Anna Pollack *Epidemiology*

Expertise in:

- Epidemiologic methods
- Reproductive epidemiology
- Environmental epidemiology

## Jenna Krall *Statistics*

Expertise in:

- Statistical methods
- Data integration
- Exposure estimation
- Air pollution

## Vivian Motti *Human computer interaction*

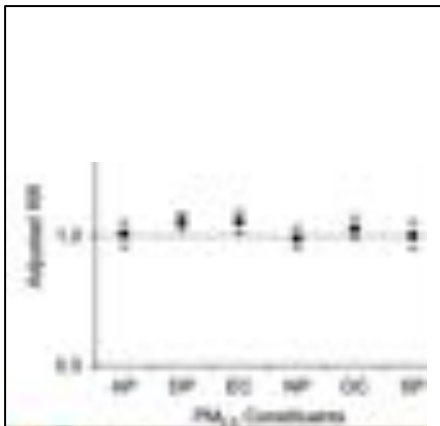
Expertise in:

- Wearable computing
- User interfaces
- User studies
- Mobile health

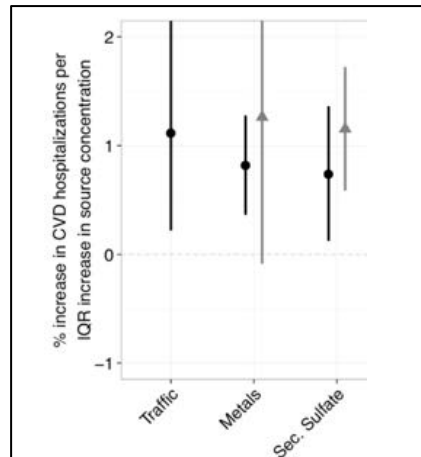
## Yi-Ching Lee *Psychology*

Expertise in:

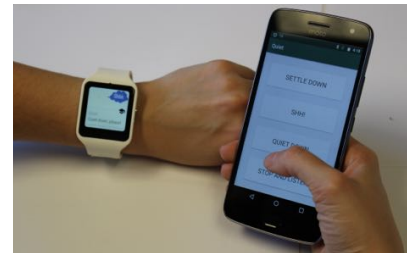
- Human factors
- Study design
- Human subjects research
- Driving behavior



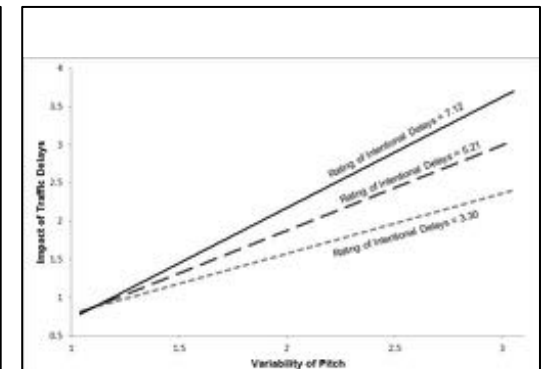
*Zhu et al. (2017) AJE*



*Krall et al. (2017) EHP*



*Zheng & Motti (2017) HCII  
Wearable LIFE*



*Lee & LaVoie (under review) TRF*

### Internal team:

Cara Frankenfeld, Associate Professor, Epidemiology  
Daniel Tong, Research Professor, CSISS  
Vadim Sokolov, Assistant Professor, Engineering  
Graduate research assistants (GRAs)  
Leah Babin, Global and Community Health  
Andrea Carmichael, Global and Community Health

*Dipleen Kaur, Global and Community Health*

*Nilofar Kantalari, Information Science and Technology*

### External team:

Roger Peng, Johns Hopkins, Biostatistics  
Pauline Mendola, NICHD, Epidemiology  
Jonathan Thornburg, RTI, Exposure Science

# Proposed budget and description

Class	Item	Description	Cost
Research team	Full-time graduate research assistant (GRA): Leah Babin (20 hours/week)	IRB submission, participant recruitment, data cleaning and preparation, analysis	\$18,000
	Travel compensation for GRA	Travel for recruitment/data collection	\$500
Exposure assessment	3 MicroPEM™ exposure monitors on loan from RTI		***RTI: est. \$6,000
	Training for GMU faculty		***RTI
	Laboratory costs for MicroPEM™	MicroPEM™ filters, flowmeter, batteries, tweezers, wipes, refrigeration	\$5,000
	In-vehicle data logger	Speed limit map development	\$3,000
Research materials	Participant recruitment	Postcards, advertising	\$1,000
	Compensation for study subjects	Amazon incentives	\$2,500
	Research trip for RTI training	Training for exposure assessment	\$3,000
	Research computers	To ensure confidential data storage, enable efficient computation of statistical models	\$4,000
	Software and analysis	Amazon EC2 cloud, statistical analysis tools	\$1,000
Total			\$38,000

\*\*\*Partnership with RTI: We agree to

- Provide RTI all raw, processed, and analyzed MicroPEM™ datafiles.
- Include RTI as co-authors on resulting publications/presentations and include RTI as collaborator on proposals submitted using these data.
- Be financially responsible for any damage to the MicroPEM™s beyond the normal wear from routine use.



# Project outcomes

		2017	2018			
Item	Description	Q4	Q1	Q2	Q3	Q4
Study planning	IRB submission, MicroPEM™ training, material acquisition					
	Study recruitment and data collection					
Statistical method development	Integration of observed, modeled pollution data					
Visualization tools	Create visualization methods and application tools					
Manuscript to <i>Biostatistics</i>	Krall: Statistical methods for estimating exposure to PM <sub>2.5</sub> during daily commutes					
Manuscript to <i>Environmental Health Perspectives</i>	Pollack: Gestational exposure to PM <sub>2.5</sub> during daily commutes					
Manuscript to <i>Transportation Research Part F: Traffic Psychology and Behaviour</i>	Lee: Commute behaviors and beliefs during pregnancy					
National Institute for Environmental Health Sciences (NIEHS) R15	PI: Krall. Statistical methods for estimating in-vehicle exposures					
NIEHS R01	PI: Pollack. Traffic-related air pollutants and birth outcomes					
National Institute for Child Health and Human Development (NICHD) R21	PI: Lee. Commute behaviors and adaptations during pregnancy					

# Future work

Future work: Mobile and wearable applications with spatiotemporal information

Novel study of in-vehicle exposures to TRAP during pregnancy



Novel visualization tools to bring information back to women



Future work:  
Associations between TRAP and pregnancy-related health outcomes

*Partnership with RTI*

Novel statistical methods for estimating exposure to TRAP during commutes



Future work: Extend predictive models to chemical constituents and gaseous pollutants

*Partnership with RTI*